USGS Ground Water Resources Program

Karst Hydrology Initiative Project

Ground Water Resources Program (GWRP)

National program initiated in 1997 by the Office of Ground Water to support:

- Regional studies of ground-water systems, particularly shallow aquifers.
- Evaluation of critical ground-water issues.
- Improved access to ground-water data.
- Ground water research and methods development.

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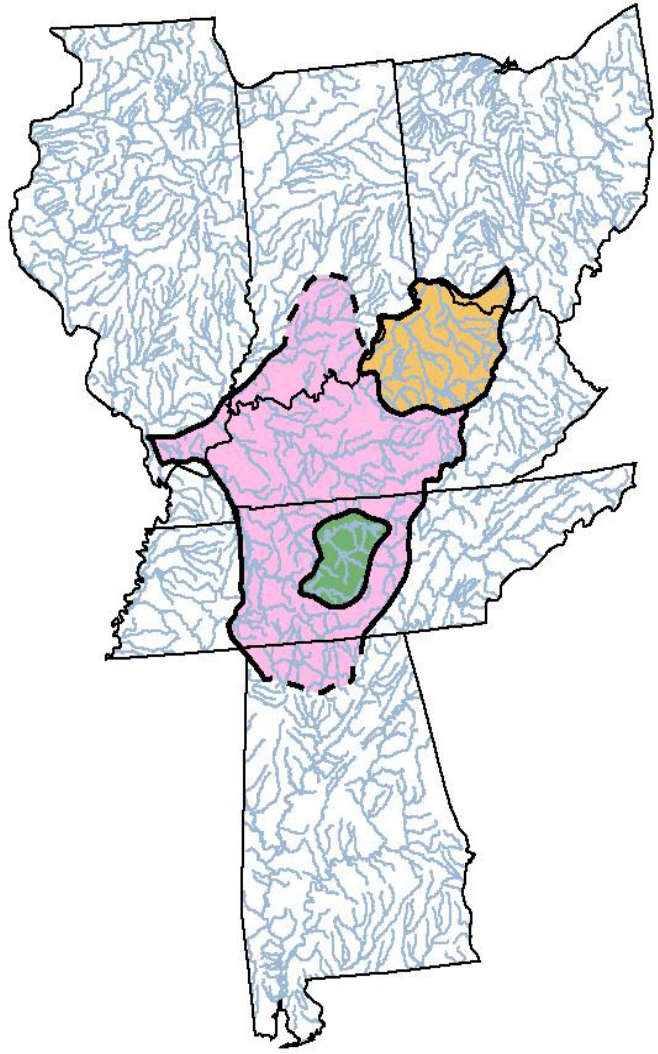
Karst Hydrology Initiative (KHI) Project

- Planned multi-year study effort
  - Collect and synthesize karst hydrologic data for Interior Low Plateaus region (AL, IN, IL, KY, & TN).
  - Gain better understanding the hydrology of conduit-dominated karst flow systems (integrated SW & GW).
  - Develop or improve analytical and decision-support tools for karst hydrology.



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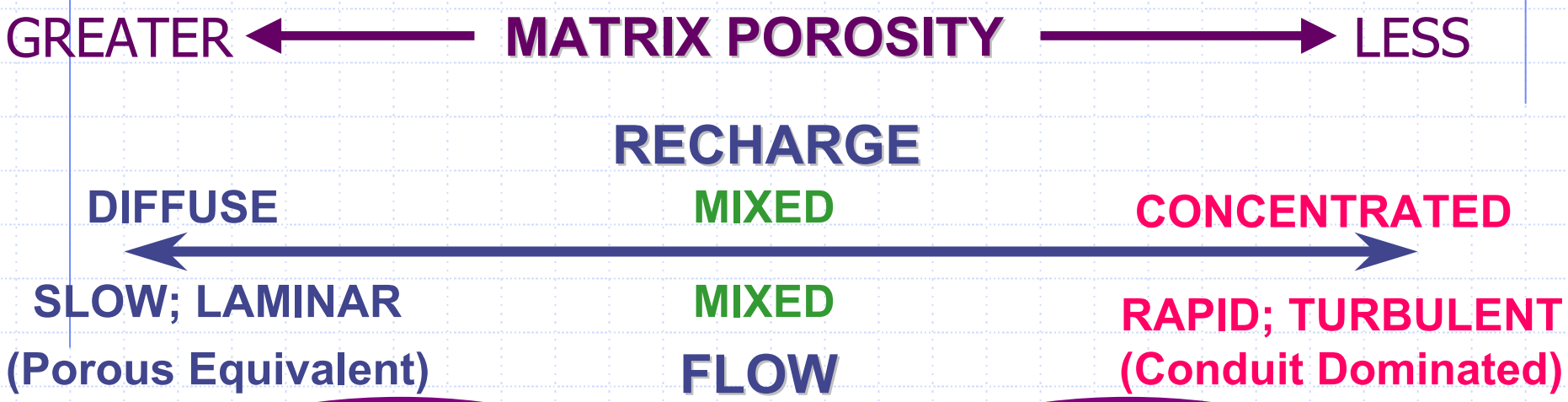
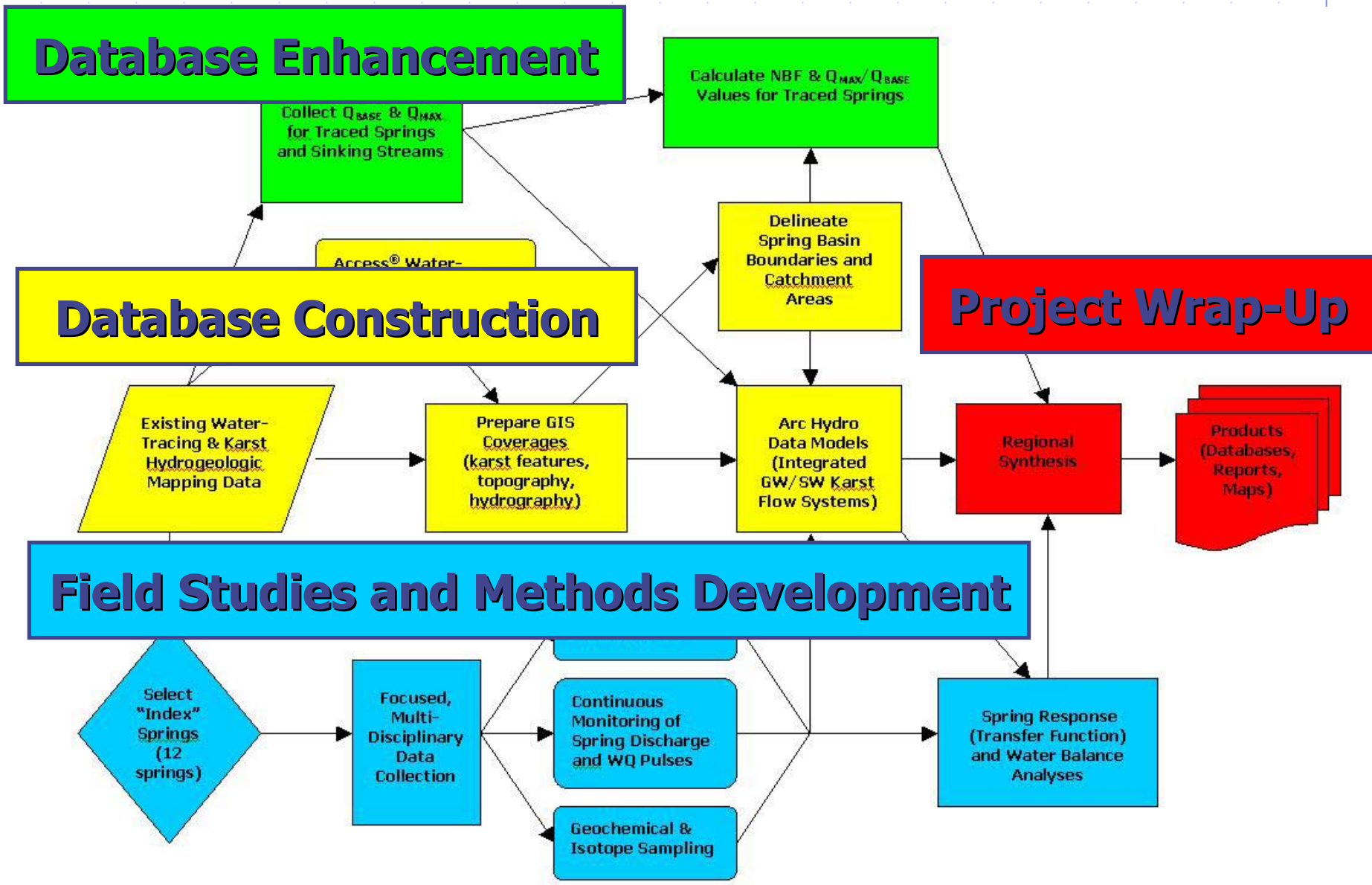
The Karst Aquifer Continuum



Traditional GW test and modeling methods work well.

Traditional GW test and modeling methods do not work well.


Database Enhancement
Collect Q_{BASE} & Q_{MAX} for Traced Springs and Sinking Streams
Calculate NBF & Q_{MAX}/Q_{BASE} Values for Traced Springs
Database Construction
Access® Water-
Delineate Spring Basin Boundaries and Catchment Areas
Project Wrap-Up
Existing Water-Tracing & Karst Hydrogeologic Mapping Data
Prepare GIS Coverages (karst features, topography, hydrography)
Arc Hydro Data Models (Integrated GW/SW Karst Flow Systems)
Regional Synthesis
Products (Databases, Reports, Maps)
Field Studies and Methods Development
Select "Index" Springs (12 springs)
Focused, Multi-Disciplinary Data Collection
Continuous Monitoring of Spring Discharge and WQ Pulses
Geochemical & Isotope Sampling
Spring Response (Transfer Function) and Water Balance Analyses

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Database Construction

Collect existing water-tracing and other selected hydrogeologic data and develop a regional karst database using GIS technology.

- Avoid duplication of effort at state level.
- Complement and collaborate with existing state programs.
- Will collect and synthesize as much of these data, & make use of existing GIS coverages, as possible.

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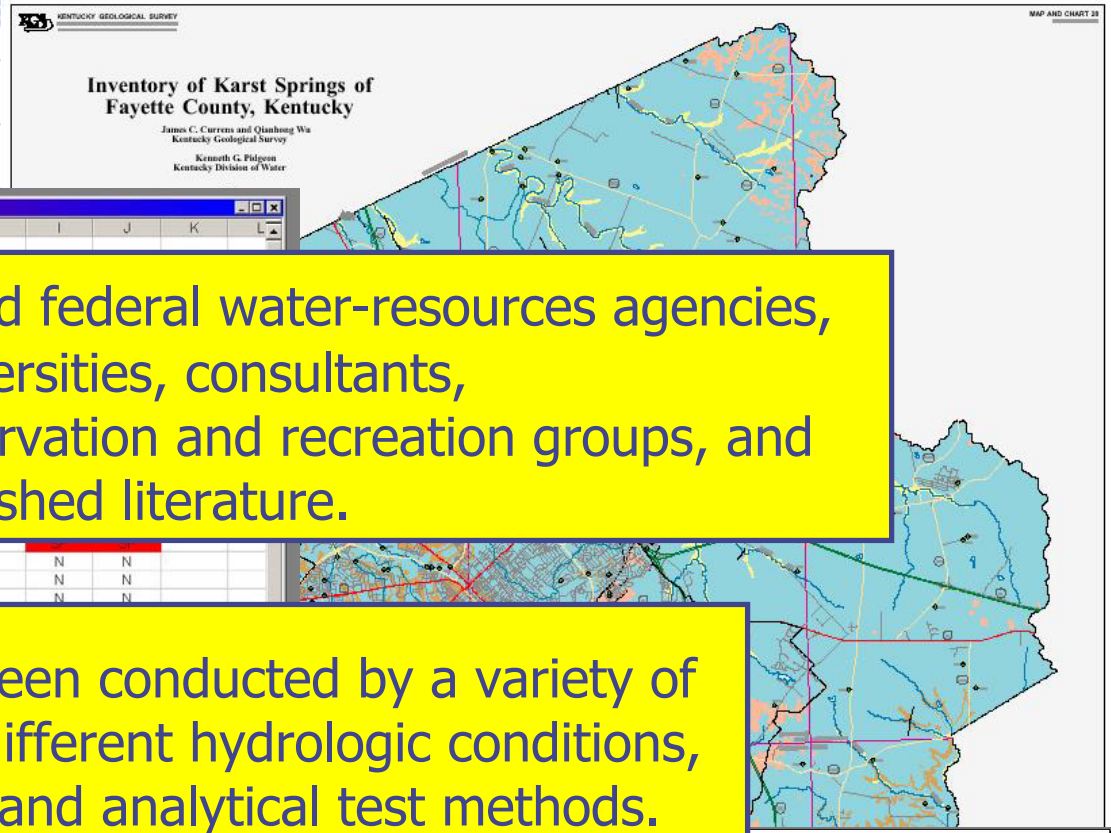
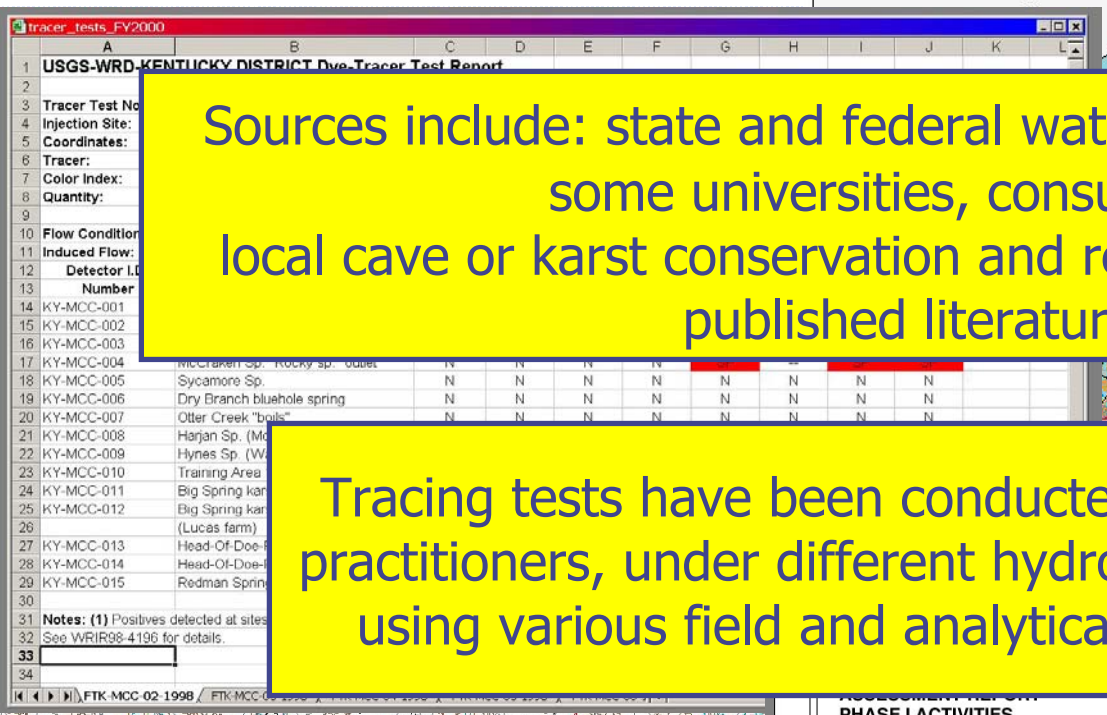
"Mining" Existing Data:





Sources include: state and federal water-resources agencies, some universities, consultants, local cave or karst conservation and recreation groups, and published literature.

Tracing tests have been conducted by a variety of practitioners, under different hydrologic conditions, using various field and analytical test methods.

Developing an Access© tracer test database for data storage and management.

MAPPED KARST GROUND-WATER BASINS IN THE LEXINGTON 30 X 60 MINUTE QUA

James C. Currens
Kentucky Geological Survey

Joseph A. Ray
Kentucky Division of Water

PHASE I ACTIVITIES
U.S. ARMY ARMOR CENTER
AND FORT KNOX

US Army Corps of Engineers

NASHVILLE DISTRICT

CONTRACT No. DACA62-94-D-0029
DELIVERY ORDER 045

November 1999

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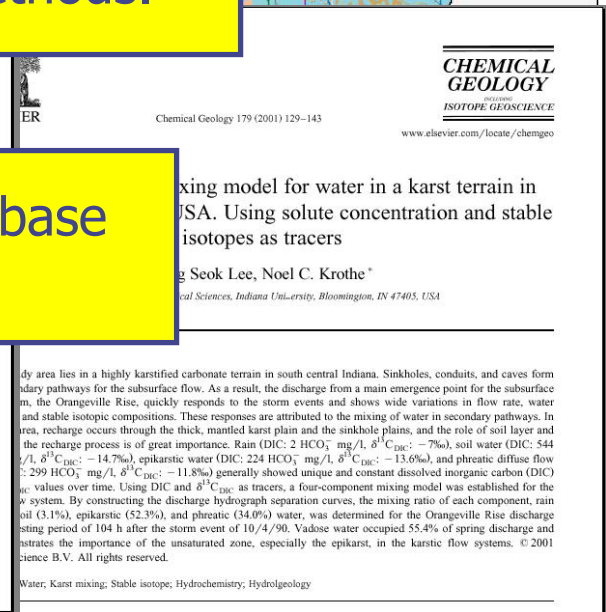

CHEMICAL GEOLOGY
ISOTOPE GEOSCIENCE

Chemical Geology 179 (2001) 129–143

www.elsevier.com/locate/chemgeo

xing model for water in a karst terrain in
USA. Using solute concentration and stable
isotopes as tracers

g Seok Lee, Noel C. Krothe *

cal Sciences, Indiana Uni..ersity, Bloomington, IN 47405, USA

dy area lies in a highly karstified carbonate terrain in south central Indiana. Sinkholes, conduits, and caves form
ndary pathways for the subsurface flow. As a result, the discharge from a main emergence point for the subsurface
m, the Orangeville Rise, quickly responds to the storm events and shows wide variations in flow rate, water
and stable isotopic compositions. These responses are attributed to the mixing of water in secondary pathways. In
rea, recharge occurs through the thick, mantled karst plain and the sinkhole plains, and the role of soil layer and
the recharge process is of great importance. Rain (DIC: 2 HCO_3^- mg/l, $\delta^{13}C_{DIC}$: −7‰), soil water (DIC: 544
/l, $\delta^{13}C_{DIC}$: −14.7‰), epikarstic water (DIC: 224 HCO_3^- mg/l, $\delta^{13}C_{DIC}$: −13.6‰), and phreatic diffuse flow
: 299 HCO_3^- mg/l, $\delta^{13}C_{DIC}$: −11.8‰) generally showed unique and constant dissolved inorganic carbon (DIC)
$_{DIC}$ values over time. Using DIC and $\delta^{13}C_{DIC}$ as tracers, a four-component mixing model was established for the
w system. By constructing the discharge hydrograph separation curves, the mixing ratio of each component, rain
oil (3.1%), epikarstic (52.3%), and phreatic (34.0%) water, was determined for the Orangeville Rise discharge
sting period of 104 h after the storm event of 10/4/90. Vadose water occupied 55.4% of spring discharge and
nstrates the importance of the unsaturated zone, especially the epikarst, in the karstic flow systems. © 2001
cience B.V. All rights reserved.

Water; Karst mixing; Stable isotope; Hydrochemistry; Hydrolgeology

Database Construction

- Use ArcHydro© to build GIS-based data models capable of managing karst geospatial and time-series data.
  - "Dynamic" mapping of flow directions and catchment areas of karst spring basins.
  - Integrates surface and subsurface flow regimes (Natl. Hydrographic Dataset stream reaches and watersheds).
  - Provides foundation for advanced water balance & basin hydrology studies, as well as a possible framework for future modeling efforts.

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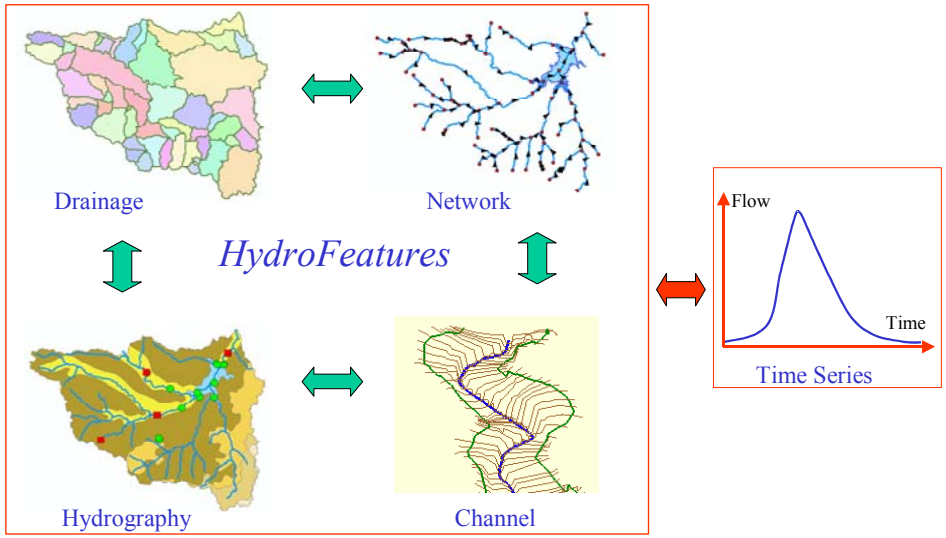
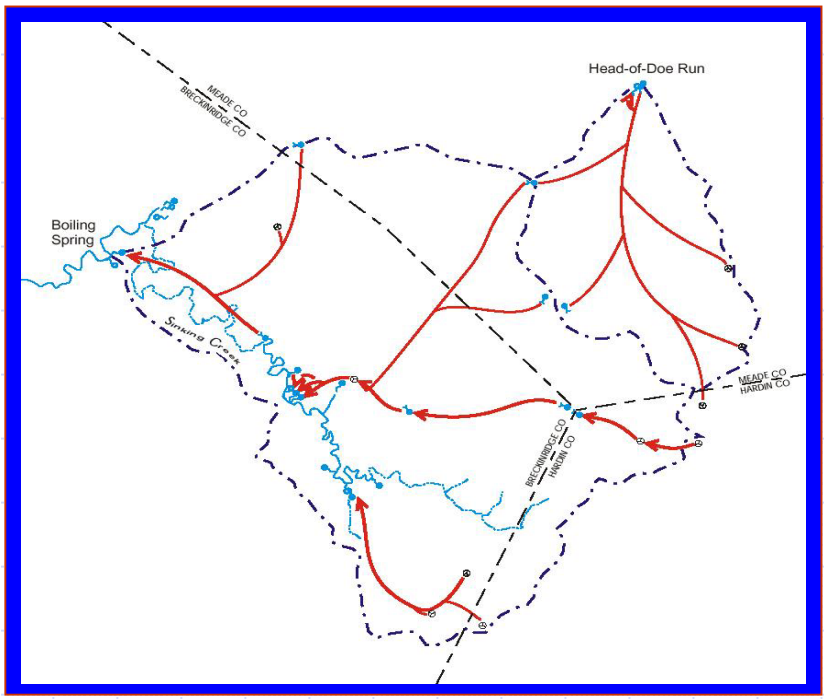
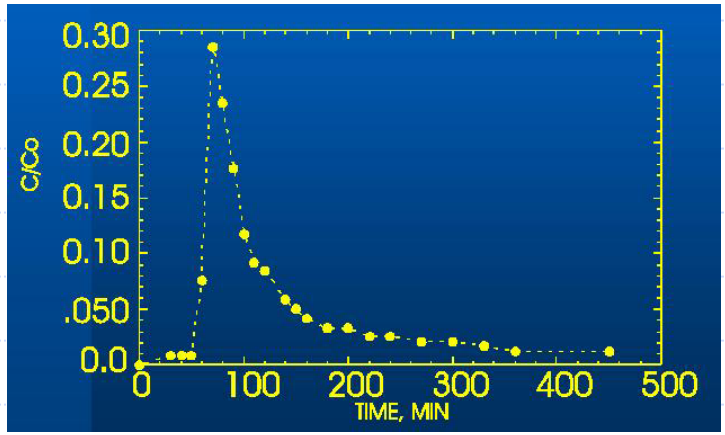
ArcGIS Hydro Data Model



ArcHydro features and functions are designed for surface streams but can be modified to represent conduit-dominated karst basins.





Database Enhancement

Collecting base-flow and high-flow discharge measurements from traced springs and sinking streams.

- Fundamental data needed for regional synthesis.
- Normalized base flow (NBF) and other karst hydrology indicators.

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Field Studies

Conduct focused hydrologic studies to help characterize regional variability in recharge, storage, and discharge of karst spring basins.

- Select up to 12 "index" spring basins to study.
- Use multiple, complementary study methods.

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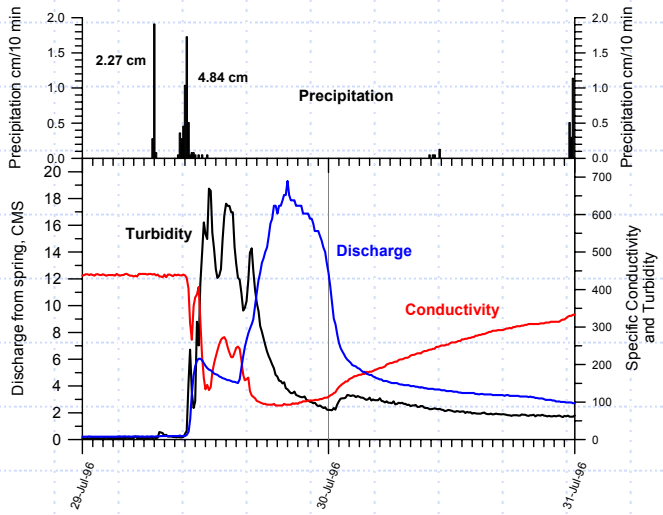
Index Springs Data Collection:

- Quantitative dye-tracer tests
  (dye breakthrough curves)
- Continuous Discharge & Hydrologic Pulse Monitoring
  (Temp, Sp. Conductance, pH)
- Geochemical isotope sampling
  (O-18, H-2, DIC, C-13$_{DIC}$, SO_4)



Discharge hydrograph and chemograph for the July 1996 high-flow event at Pleasant Grove Spring.

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Methods Development

Research and evaluate new methods for spring response and water balance analyses, including transfer functions and catchment hydrology models, as tools for characterizing regional karst hydrology.

USGS

Methods Development

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Excellent tools for investigation & quantitative characterization of spring and basin hydrologic properties.

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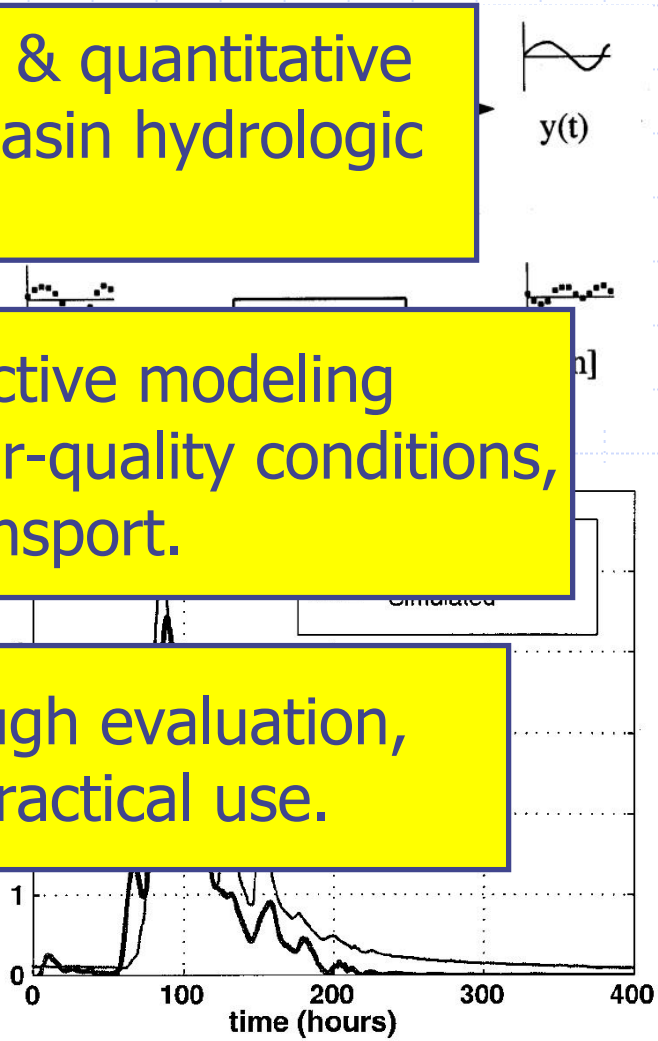
Show great promise for predictive modeling of changes in storage & flow, water-quality conditions, and contaminant transport.

pulse, and geochemical isotope data).

- N

Need refinement, more thorough evaluation, and simplification to be of practical use.

models (TOPMODEL, GNNs, etc.).



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An Overarching Project Goal:

Facilitate and strengthen collaboration between USGS, other federal and state agencies, universities, and other karst research and resource-management groups.


Stronger collaboration will improve:
➢Identification of karst research needs.
➢Collection and analysis of karst data.
➢Data accessibility and usefulness.

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